~~176/90~~ 376/903

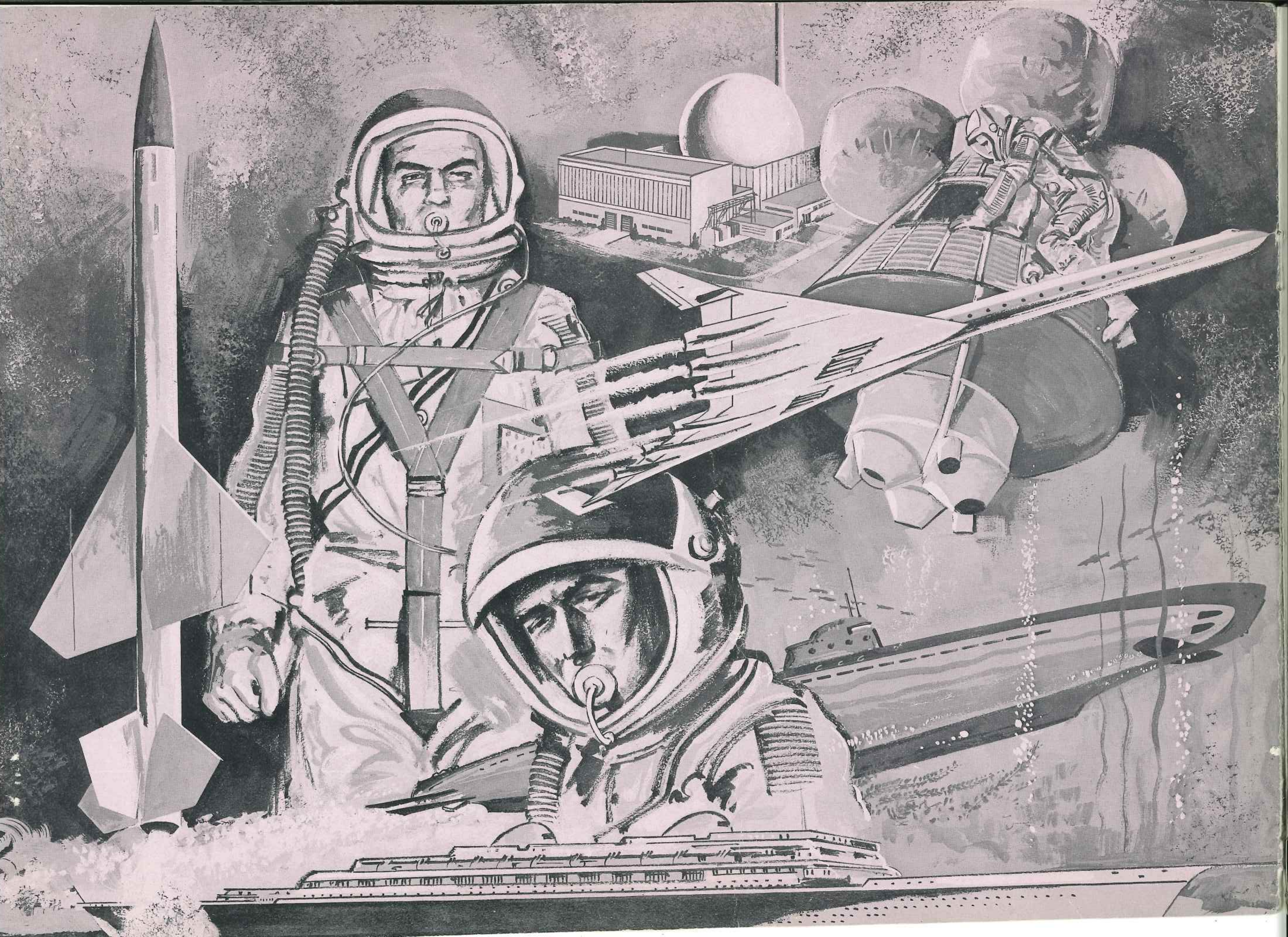
68, 89, 82, 69

Screen &
honeycomb
shapes
(Fig 6-8)

3M BRAND

REACTOR MATERIALS

Si - Si
SiC
Pyrolytic C
UC_2, ThC_2
UC_2
B_4C



3M BRAND REACTOR MATERIALS

At 3M Company, high temperature reactor materials technology is being advanced. Materials of the following general types are being developed and produced:

1. Reactor fuel microspheres
2. High surface area fuel elements
3. Graphite fuel elements

The accent is on ceramic, cermet or refractory metal materials. Although the 3M group is currently interested in most of the nuclear fuel areas, it is principally active in the above listed areas of high-temperature reactor materials. These include honeycomb (high surface area) ceramic elements, honeycomb metal elements, coated graphite fuel elements, and spherical particles such as UC_2, ThC_2UC_2, and B_4C. Fueled materials can be provided in either normal or enriched uranium types. Work can be handled on either the Licensee status or on an Accountability Station basis.

REACTOR FUEL MICROSPHERES

3M Brand Fueled Microspheres offer a new approach to the incorporation and dispersion of high-performance nuclear fuels in high-temperature reactor systems.

Figure 1 Microspheres (UC_2)

DISPERSION FUEL

In dispersion fuel technology, spherical particles offer the advantage of greater strength or fracturing resistance and minimum surface area over particles of irregular shape. High strength and fracturing resistance are important in preventing fuel particle breakup during fabrication of dispersion fuel elements. Minimum surface area decreases the degree of reaction between fuel particles and matrix materials, as well as facilitates handling, by reduction in the amount of reactivity in contact with air. Other advantages are reduced pyrophoricity and improvement in free-flowing characteristics.

The 3M Brand Fueled Microspheres are available in any size range within 30 to 500 microns. They are available as UC_2 or as ThC_2-UC_2 micro spheres. Thorium to uranium ratio can be varied according to requirement.

The Microspheres are available also as the burnable reactor poison B_4C. This burnable poison constituent can be utilized in dispersion fueling in mixture with the UC_2 or the ThC_2-UC_2 microspheres. Figure 1 shows an enlargement of some typical UC_2 microspheres.

COATED PARTICLES

Certain conditions of fuel microsphere use may make it desirable to protect the particle from atmospheric corrosion or other environmental problems. In these cases it is possible to provide the Microspheres with a coating of specific thickness. This same coating may also serve as a retention barrier for fission products. The primary material now employed in forming these barriers is pyrolytic carbon. Figure 2 shows UC_2 Microspheres coated with 3M Pyro carbon. Refractory metals and their carbides can also be used and deposited as protective coatings over the microspheres. Such a typical coating is Niobium Carbide.

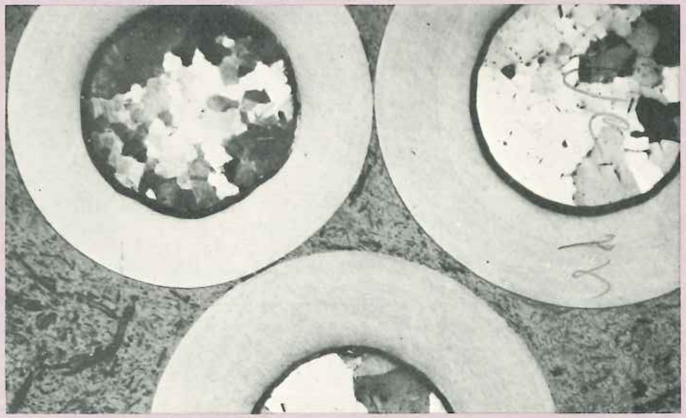


Figure 2 Pyro carbon Coated Microspheres (UC_2) (X250)

The coated Microspheres may then be used as such or further incorporated as discrete fuel particles in another matrix. In particular, Pyrocarbon coated carbide fuel microspheres can be advantageously employed in graphite matrixes.

OXIDE FUEL PARTICLES

For dispersion fueling in metal fuel element systems, 3M can provide UO_2 rounded particles. These also can be protected with surface coatings, if desired.

MICROSTRUCTURE

Microstructure of the UC_2 and the ThC_2-UC_2 Microspheres can be varied so as to yield several specified microstructures. For example, Microspheres can be specially produced wherein (1) there are no straie in the particles, or (2) the particles are of single crystal type, or (3) the particles are of multi-grain type. Grain size can be controlled so that the individual grains within particles are either smaller or larger than as shown in Figure 3.

Figure 3 Microspheres (UC_2) (X62.5)

GRAPHITE FUEL ELEMENTS

3M Nuclear Products has for several years been a participant and a contributor to the rapidly advancing graphite fuel element technology. Following are the highlights of significant 3M contributions to this technology:

1. Siliconized Silicon Carbide Coating (Si-SiC)
2. Graphite base, dispersion type elements, incorporating UC_2, ThC_2-UC_2 and B_4C Micro-spheres, coated with Pyrocarbon
3. Non-fueled graphite shells surrounding fuel cores of UC_2 graphite fuel elements

The graphite fuel elements can be provided in the following shapes:

1. Solid cylindrical pellets
2. Hollow cylindrical pellets
3. Spheres, pebble bed reactor type
4. Special shapes
5. Honeycomb graphite shapes

Figure 4 Micrograph of Si-SiC Coating on Graphite (X250)

Figure 5 shows fueled graphite elements of the pebble-bed sphere and cylindrical pellet varieties.

Graphite fuel elements can be provided wherein fueling of the element utilizes either (1) UC_2 fuel formed in situ, or (2) UC_2 or ThC_2-UC_2 Micro-spheres, Pyrocarbon or refractory metal carbide coated, if desired.

It may be desirable, for fission product retention purposes, to surround the fueled core of a graphite fuel element or pellet, with an unfueled shell of graphite. This feature can also be provided.

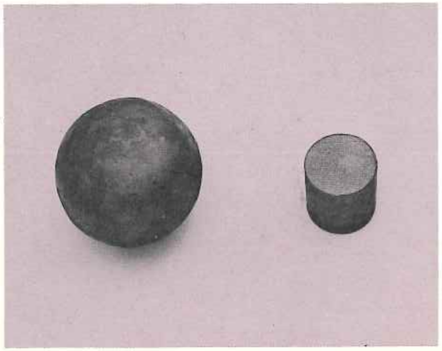


Figure 5 Coated Graphite Fuel Elements

PROTECTIVE COATINGS

Graphite fuel elements made at 3M Company facilities can be protectively coated with a proprietary Siliconized Silicon Carbide coating.

The 3M coating of Si-SiC provides long term oxidation protection for high temperature applications up to 1000°C. Short term protection is provided at higher temperatures. The coating also serves as a fission product retention barrier, and would assist in preventing catastrophic steam-graphite reaction.

Since graphite has exceptional thermal shock resistance and strength at elevated temperatures, these advantages combined with the oxidation resistance of the coating makes the 3M coated graphite well suited for its nuclear applications. Figure 4 shows the Si-SiC coating, magnified in cross-section.

Other materials and articles can be equally well fabricated of graphite, and protectively coated with the 3M Si-SiC process. Typical of these are (1) Moderator blocks and (2) Structural components.

HIGH SURFACE AREA FUEL ELEMENTS

Honeycomb fuel elements of many configurations can be fabricated by a revolutionary process proprietary to the 3M Company, to meet developmental concepts.

Typical of the types of high-surface area honeycomb fuel elements are:

1. Honeycomb oxide-base elements (Al_2O_3, ZrO_2, cordierite, etc.)
2. Honeycomb graphite-base elements
   These can be provided with or without the Si-SiC coatings and with or without an active core of UC_2 or ThC_2-UC_2.
3. Honeycomb metal-base elements
   Typical of these are stainless steel, tungsten, tantalum, molybdenum, and niobium.

   These can be provided with or without an active core or fueled zone incorporating enriched or normal uranium oxide particles.

Figures 7 and 8 show representative specimens of such honeycomb elements.

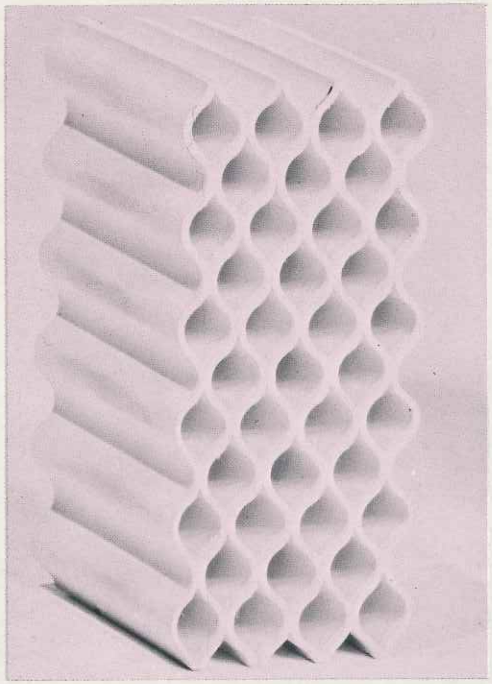


Figure 6 High Surface Area Elements

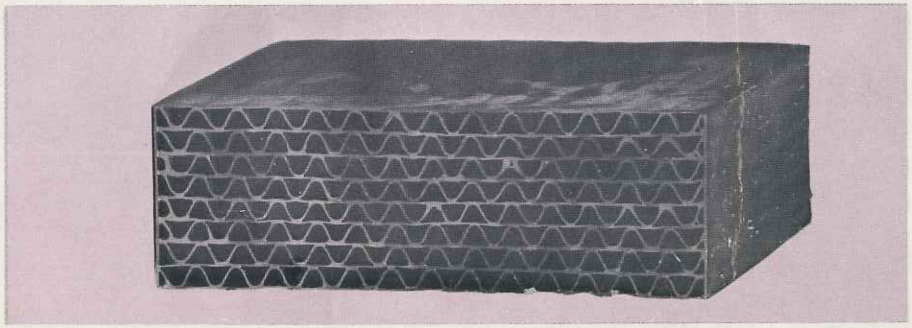


Figure 7 High Surface Area Elements

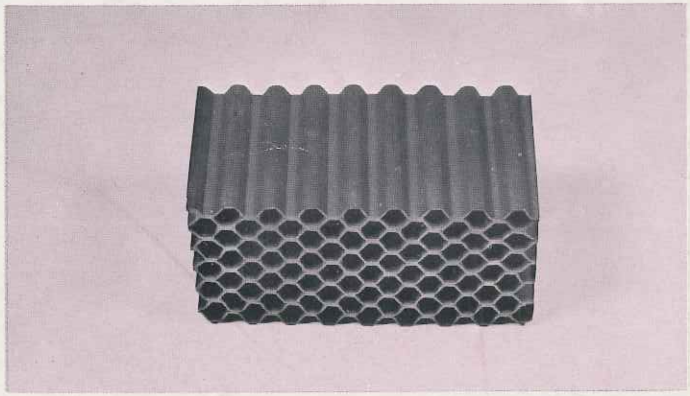


Figure 8 High Surface Area Elements

3M

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